Area Source Ammonia Reasonably Available Control Technology (RACT)

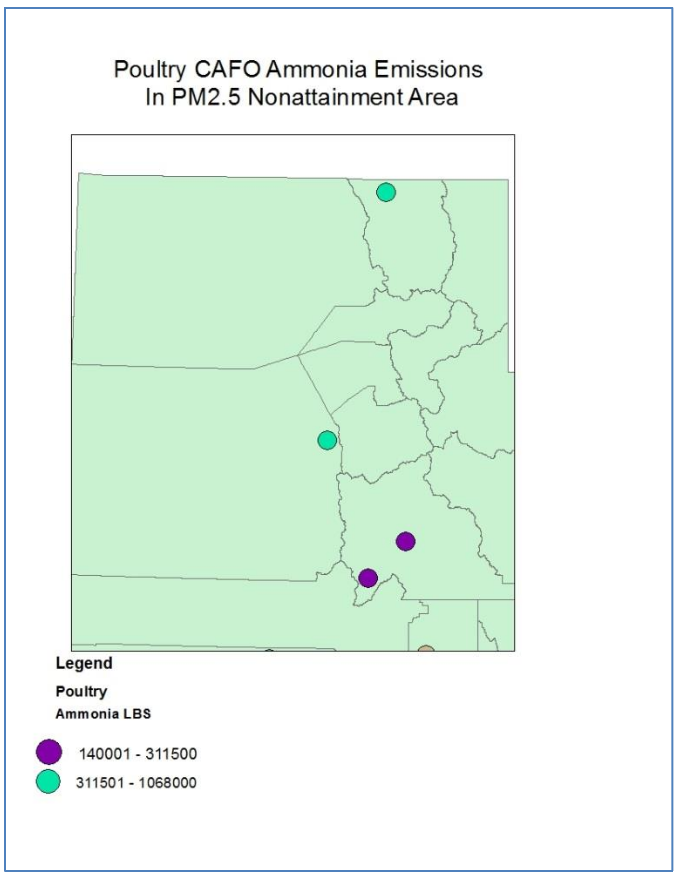
EPA defines RACT as the lowest emission limitation that a particular source is capable of meeting by the application of control technology (i.e., devices, systems, process modification, or other apparatus or techniques that reduce air pollution) that is reasonably available considering technological and economic feasibility.

This section provides a discussion on ammonia control strategies that are technologically feasible for winter-time manure management. Manure injection and soil incorporation (including chemical treatments prior to land application) are not included as manure management strategies because these activities cannot be performed when the ground is frozen.

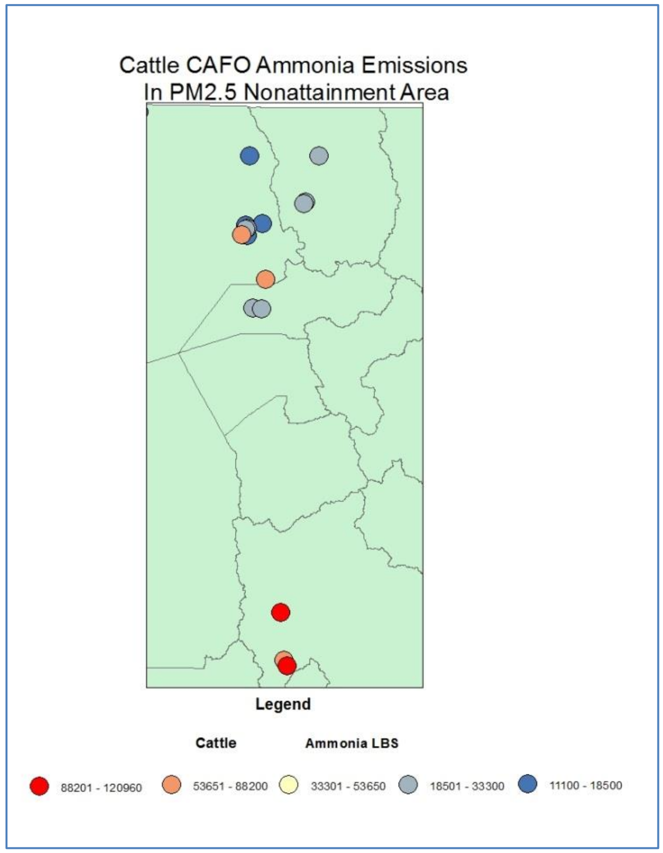
Ammonia Inventory

There are many winter time source categories of ammonia within the nonattainment area source inventory. According to the non-point source 2011 national emissions inventory (NEI) for Utah, most of the sources are relatively small and less than 10% of the inventory can be attributed to these small sources. The smaller sources include human respiration, domestic animals, combustion of natural gas and wood burning, public wastewater treatment and consumer products. The remaining ammonia categories within the nonattainment area are attributed to wildlife (10%), such as deer and 79% from livestock and poultry. Within that 79% of the inventory; cattle (60%) and poultry (29%) are the largest ammonia sources. The remaining 11% is from miscellaneous livestock such as goats, sheep and horses. Consequently, the area source control strategy will focus on commercial cattle and poultry operations.

Commercial poultry operations within the nonattainment area are limited to egg laying production. There are no commercial broiler operations or turkey growers. Ammonia emissions for the larger poultry operations can be calculated using the CAFO database and AP-42 factors. The four poultry CAFO operations within the nonattainment area are shown in the figure to the right. There are two in Utah County, one in Box Elder County and one in Cache County.



Cattle operations within the nonattainment area include dairy and beef production. The cattle CAFO's and their ammonia emissions are shown in the figure to the right. There are three sources in Utah County, two in Weber County, seven in Box Elder County and two in Cache County.



Ammonia Characteristics in Manure

Agriculture is responsible for over three-fourths of the ammonia emissions in the USA and Canada, with animal production accounting for the major share. Ammonia becomes a constituent of animal waste when nitrogen-rich protein in feed is not completely converted into animal products (such as meat, milk, wool, and eggs). For example, only 25 to 35% of the nitrogen fed to dairy cows is converted into milk, with the remainder excreted in urine and manure in a variety of simple and complex forms of nitrogen. Chemical and microbial processes release ammonia into the air. Nitrogen in poultry manure is mainly in the form of uric acid, which also rapidly converts to urea and to ammonia (Bittman and Mikkelsen, 2009).

Ammonia is a colorless, lighter than air gas with a pungent odor. Significant volatilization of ammonia can occur within the first 24 hours after land application of manure. More than 50% of the total emission of ammonia can occur within the first six hours after application. Ammonia volatilization is highly dependent on manure management techniques and environmental factors, such as temperature and wind. Researchers have found that 50% of total nitrogen is volatilized as ammonia at a temperature of 30°C compared to 35% volatilization when the temperature is 25°C. Wind speed will increase the rate of ammonia volatilization as the higher wind increases the mass transfer and air exchange between the manured surface and the atmosphere. (AGRI-FACTS, Agdex 538-3, February 2008).

Summary of Other State Rules

A search was conducted of state rules designed to control agricultural ammonia sources. The following state rules have been identified:

- South Coast Air Quality Management District (SCAQMD): Rule 1127 - Emission Reductions from Livestock Waste. The rule is intended to control ammonia, VOC, and PM10 from dairy farms and associated cattle operations, composting operations and anaerobic digesters. The rule requires the use of best management practices (BMPs) for manure collection, minimization of water usage in corrals, manure disposal, manure disposal, composting and feed stock preparation. Sources may propose alternative control options.

- SCAQMD: Rule 1133.2 - Emission Reductions From Co-Composting Operations. The rule is intended to control ammonia and VOC from all co-composting operations. Co-composting is defined as composting where biosolids and/or manure are mixed with bulking agents to produce compost. Co-composting includes both the active and curing phases of the composting process. The rule requires that all active co-composting be confined within a controlled enclosure with a controlled vent that permits no more than 20% release by weight.

- San Joaquin Valley Air Pollution Control District: Rule 4565 - Biosolids, Animal Manure, and Poultry Litter Operations. While this rule is intended to control VOC from operations involving the management of biosolids, animal manure, or poultry litter, certain provisions may also be helpful in controlling ammonia. This rule only applies to major sources whose throughput consists entirely or in part of biosolids, animal manure, or poultry litter and the operator who landfills, land applies, composts, or co-composts these materials. The requirements include operational constraints, the use of covers and 80% VOC control efficiency.

- Idaho permit by rule for dairy farms (IDAPA 58.01.01): The rule applies to dairy farms with a capacity to produce 100 or more tons of ammonia emissions per year. The rule prescribes various BMPs to control ammonia emissions, ranging from installing certain types of waste storage and treatment systems to implementing composting practices to exporting manure. A point value is assigned to each BMP. Dairy farms must employ BMPs totaling 27 points. The Idaho BMP's are in line with the control strategies discussed in the next section.

Ammonia Control Strategies in Livestock and Poultry Manure

Dietary Manipulations

Excess nutrients not absorbed in the digestive tract are voided in the manure and urine. Dietary protein provides amino acids, nitrogen, sulfur, and other elements needed for animal reproduction, growth, and milk or egg production. Animals use less than half of the nitrogen that they consume, with the remaining excreted in the feces or urine. Fecal and urinary nitrogen are ammonia emission sources. Limiting crude protein levels in the diet to only that used by the animal limits nitrogen excreted in urea or uric acid, which contributes to emissions.

While reducing crude protein content will reduce nitrogen excretion and ammonia emissions, reductions in crude protein can severely impact animal performance. To effectively reduce crude protein concentrations of diets for poultry, additional supplementation of synthetic amino acids is needed. Animals require a specific ratios of available amino acids; thus, lowering crude protein levels requires supplementation with select amino acids that otherwise would be insufficient. Specific synthetic amino acids can be added to meet the nutritional needs of an animal according to genetic lines, age, sex, and other factors (Air Quality Education in Animal Agriculture, January 2012).

Research has shown that high-quality, protein-limited diets with appropriate supplementation of amino acids can effectively reduce nitrogen excretion and ammonia emissions from poultry, dairy and beef cattle operations without a loss in animal productivity. Commonly used amino acids are lysine, methionine, and threonine. Other amino acids may not be economically feasible (Applegate et al., 2008).

Researchers have found that for every one percent reduction in crude protein, there is an 8.5-10% reduction in ammonia in dairy beef and poultry. Addition of fermentable carbohydrates (bran or pulp) results in a 14% ammonia reduction (Iowa State Univ. Extension, 2004).

Undesirable sulfurous compounds often originate from sulfur-containing amino acids and sulfur-containing mineral sources. Limiting unnecessary sources of sulfur can reduce emissions of hydrogen sulfide and other volatile sulfur compounds (Air Quality Education in Animal Agriculture, January 2012).

Ultimately producers formulate their own feed and may rely on feed ingredients based on lowest market cost that will result in acceptable yield. Supplementing diets with amino acids other than lysine, methionine, or threonine may not be economically feasible at this time.

Dietary manipulation for the purposes of reducing ammonia production would require monitoring of a host of physiological factors, as well as monitoring feed ratio. Given the many complex variables, we cannot develop a universal SIP enforceable standard that would yield reliable control reduction while guaranteeing productive growth and/or yield. Consequently, dietary manipulation is screened out as a viable strategy.

Manure Management

Poultry Litter Amendments

Poultry litter is a mixture of bedding materials, excrement, spilled food and feathers. Acidifying litter with aluminum sulfate (alum) creates an acidic condition in the litter that result in converting ammonia to ammonium sulfate. Additional benefits of alum amendment include phosphorous binding, killing pathogens, causes the birds to grow faster and assist in using feed more efficiently. Due to the benefits of this practice (and cost-effectiveness), over one billion broiler chickens are grown with alum each year. The United States Department of Agriculture (USDA) supports the use of alum amendment through some cost-sharing programs (direct communications with Philip Moore, USDA).

Poultry manure treatment with alum in broiler houses has been demonstrated to reduce ammonia on average by 70% (Moore et al., 1999 and 2000). Alum is normally applied between each flock of birds at a rate of two tons of alum per broiler house. Alum costs about $250/ton (USDA, *Treating Poultry Litter with Aluminum Sulfate (Alum))*.

Utah does not have commercial scale broiler houses but does have four large egg farms within the nonattainment counties. Given the successful use of alum in broiler houses, we explored the possibility of extending this control strategy for hen laying litter.

According to Philip Moore of the USDA, there has only been one good study conducted by the USDA on the use of liquid alum in high-rise laying hen houses. An automated misting delivery system was built at an Arkansas operation at a cost of $30,000. The system delivered 1,000 gallons of liquid alum per month onto the litter at a cost of

$440/month. System testing showed ammonia levels were reduced from 70-90 ppm to around 10 ppm. Ammonia flux was reduced by 33%. Moore noted that the study high-rise house had higher than normal ammonia levels than one would find in newer high-rise houses with better management practices. Consequently, the dramatic ammonia reduction in this study was attributable to the very high levels of ammonia at the study site. Feed conversion and egg production were improved with alum such that there was a net return of $426/week (excluding the capitol construction cost) (Moore et al., USDA grant report and direct communication). Moore stated during direct communications on this matter that he is not aware of any egg producer using an alum system.

This control strategy may be economically beneficial if a lower cost delivery system can be manufactured. At this juncture, there is no reliable data to support an expected control efficiency based on Moore's commentary that the ammonia levels in the project house were above normal. In the absence of verifiable control efficiency data and cost, we cannot retain this control strategy for SIP inclusion.

Mechanical Poultry Manure Processing

Automatic manure belt systems are belts that travel on rollers under egg laying hens. The belts deliver the manure to the end of the cage row where manure cross conveyors remove it from the hen house to a manure storage area. The manure can be more readily disposed of or treated on a timely basis. According to one of the larger poultry producers in Cache County and a representative of the Utah Farm Bureau, poultry houses are preferably migrating to this expensive technology because removing the manure immediately after generation greatly reduces the fly population, rodents and odor. This mechanical process in itself does not reduce ammonia volatilization but it does collect the manure in a central storage area permitting timely treatment before large quantities of ammonia can evolve.

Composting

Ammonia loss during composting depends on the carbon to nitrogen (C:N) ratio. Ammonia volatilization is significant below a C:N of 15:1. Increased use of bedding (wood shavings, straw, etc.) helps maintain a higher C:N ratio. Application of a layer of 38% zeolite, placed on the surface of a composting poultry manure, reduced ammonia losses by 44%(Iowa State University Extension, July 2004). Composting requires routine pile mixing which would likely require amendment re-application. The cost for this control strategy is based on the amendment used and would be expected to be fairly low for carbon-based amendments like straw. One of the Cache County egg producers is currently composting his chicken litter with wood shaving and straw, then selling it commercially. A representative of the Utah Farm Bureau stated that producers are composting year round and that the piles generate enough heat to be effective even in winter. Since this strategy is already in common practice, there is no reason to consider it further in the SIP.

Permeable Covers

Permeable covers, or biocovers, act as biofilters on the top of manure storage areas. Materials often used as covers include straw, cornstalks, peat moss, foam, geotextile fabric, and Leka rock. Permeable biocovers reduce emissions, in part, by reducing both the radiation onto the manure storage surface and the wind velocity over the liquid surface of the storage area. At the solution/air interface, humidity is relatively high, which creates a stabilized boundary that slows the emission rate of odorous volatiles. The aerobic zone within the biocover allows the growth of aerobic microorganisms that utilize the carbon, nitrogen, and sulfur from the emissions for growth. By further degrading and making use of these compounds prior to exiting the biocover, odors emitted from the biocover are altered and reduced. Reports of odor reductions of 40-50% are common whenever various straw materials are used. An odor reduction efficiency of 85% has been noted following the use of a floating mat or corrugated materials. Although ammonia emission reductions are undocumented, the processes that occur in the biocovers suggest that ammonia emissions may be reduced to the same extent (Iowa State University Extension, July 2004). Cost would vary greatly, with the greatest cost for a geotextile fabric.

Producers who practice composting are adding straw and wood shavings as the carbon source, essentially incorporating biocovers into their composting process. This control strategy is not retained for further consideration because it is already employed to some degree and there is no reliable data to support an expected control effectiveness value for ammonia.

Liquid-Solid Manure Separation and Storage

Because ammonia results from the interaction of urine and feces in ruminants, efforts to separate them immediately upon excretion have reduced ammonia emissions successfully (Iowa State University Extension, July 2004). The ammonia emissions reductions of urine-feces segregation in cattle has been reported to range from 21% with a 3% sloped solid floor collection (Braam et al., 1997a) to as much as 65% using a V-shaped pit floor with the gutter at the V (Braam et al., 1997b). A conveyor belt system was reported to reduce ammonia by 47-49% (Lachance et al., 2005; Stewart et al., 2004). All reported studies show ammonia reduction. The limiting factor is the cost of installing a system, maintenance, and ease versus cost of operation. Most dairies within the nonattainment area may already be using some liquid-solid separation method.

Given the structural complexity involved in installing these systems and the potential for high cost, we believe that this option is not well suited for SIP consideration, but should be encouraged as part of the USDA best management practices.

Animal Housing-Biofilters and Scrubbers

Biofiltration is a pollution control technique using living material contained on a fixed surface to capture and aerobically biologically degrade pollutants.

P.M. Ndegwa, of Washington State University, presented a review of emission mitigation techniques at the Mitigating Air Emissions from Animal Feeding Operations Conference in 2008. He reported that the literature presents a broad range of biofilter efficiencies in the removal of ammonia in carrier-air from 9-100%. The variability was attributed to the wide range of biofilter-material, bed moisture, residence time, ammonia loading and bed biological activity.

System cost in 2004 was reported to be $150—200 per 1,000 cfm of air treated. Operational cost was estimated at $0.25 per piglet, amortized over a 3-year for a 700-head farrow-to-wean swine facility. Reductions of ammonia emission at that operation was approximately 74% (Iowa State University Extension, July 2004).

Biofiltration will only work when there is a complete air capture system in place which limits this application in the nonattainment area to egg laying producers, who as an industry, have chosen to move towards installing expensive mechanical belt manure removal systems. If we assume that half of the poultry operators have not converted to a mechanical belt system and if we assume that they contribute 50% of the ammonia within the poultry category, the 2011 NEI ammonia value would be 919 tpy.

To determine the expected emission reduction, we must apply the following SIP based equation:

> Emission Reduction = [control efficiency (CE) x rule effectiveness (RE)] x rule penetration (RP)]

For the purposes of this analysis, we assume that CE equals 74% per the value reported by Iowa State.

RE is a term that describes a method to account for the reality that not all facilities will comply with a rule that establishes a required control strategy. It also accounts for the fact that control equipment does not always operate at optimum control efficiency. A default value of 80% is used for new rulemaking.

RP is a term that describes the extent to which a rule applies to a regulated population. In this case we assume 50% of the producers have not already converted to mechanical belt removal systems.

> Emission Reduction =((.74)(.80RE)) x (.50RP) = 30%
> Emission Reduction = 919 tpy x 30% = 276 tpy

The non-point source 2011 NEI total ammonia value for the nonattainment area is 11,759 tpy. The 276 tpy emission reduction would amount to a 2% annual ammonia reduction or nearly zero on a daily basis. It is important to note that this scenario is an over-simplification, best-case estimate that does not reflect actual conditions because an accurate inventory of hen houses and their emissions has not been made.

Ammonia sensitivity modeling indicates that it would require a 50% daily ammonia reduction in order to influence $PM_{2.5}$ secondary formation. Consequently, the best-case projected ammonia daily reduction from hen houses is insignificant. Therefore, this control strategy is not retained for further consideration.

Conclusion

There are numerous complex factors involved in ammonia agricultural controls, complicated by winter-time conditions, which make it impractical to derive uniform air quality rulemaking. Further, ammonia reductions from prospective rules indicate that the ammonia reductions would be insignificant and would not contribute to the SIP process. The USDA has derived manure BMPs that it encourages producers to follow and it appears that the few states that regulate agricultural ammonia have applied these BMPs. As presented above, many producers are actively engaged in BMP practices and some have an economic incentive to manage their manure in such a way as to reduce ammonia evolution (less ammonia loss results in a higher grade fertilizer) because they sell their finished compost.

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